National Aeronautics and Space Administration

Analyzing Multivariate FOQA Data during Approach: Some Success Stories

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Contributors:

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- **Representatives from partner airlines**

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- **Elizabeth Foughty**

Problem Statement

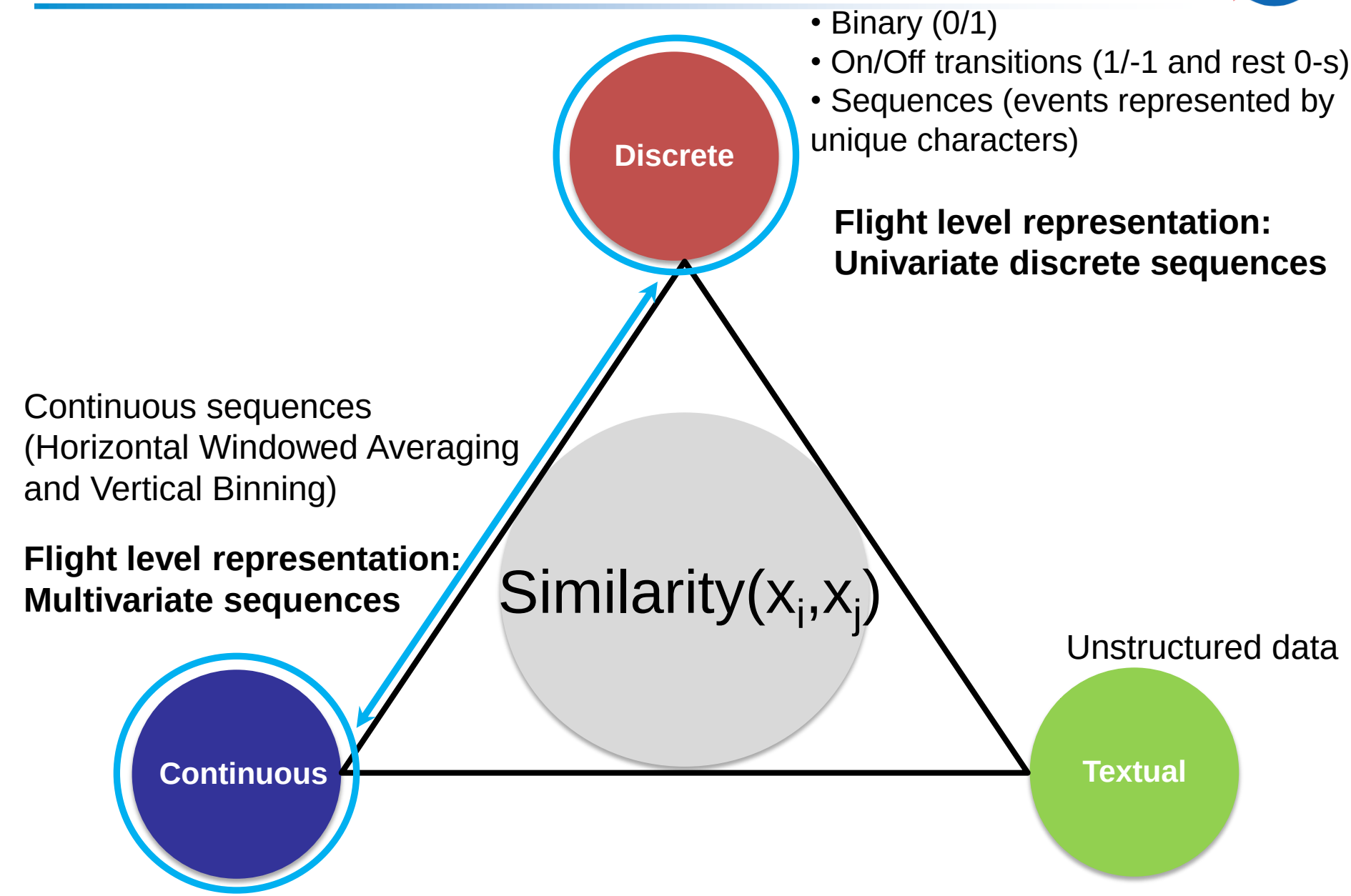
Automated identification of fleet-wide anomalies in heterogeneous flight monitoring data, taking into account flight crew performance on aircraft operations while conducting safety related analysis and studies.

Developing methods that detect/diagnose problems that occur in the interaction between the input provided in the cockpit and the system (aircraft). The system behavior is measured by several sensing devices attached with the system.

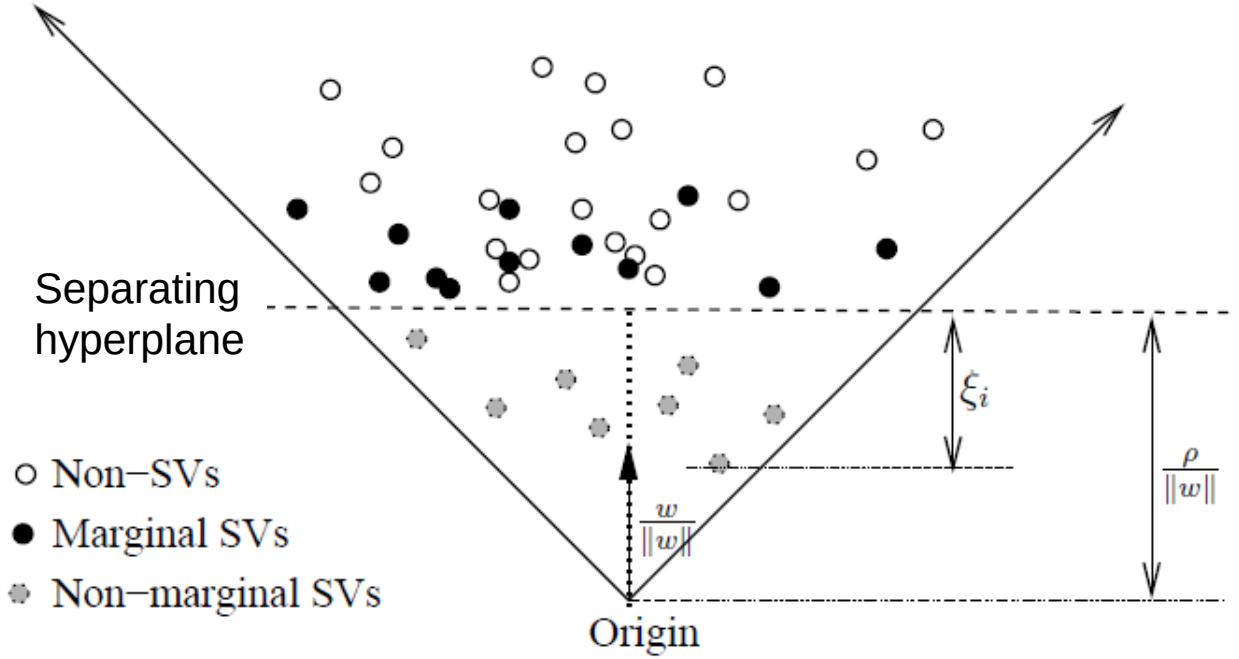
Key Characteristics:

- Combined inputs (actions) and measured variables (reactions)
- Sequence of actions
- Fleet level analysis (group of aircraft sharing generally compatible parameter list)
- Discover some “unknowns”
- Localizing unusual subsystem behavior

Mining Heterogeneous Flight Data



What is Anomalous?



Solve an optimization problem to determine the threshold (decision boundary)

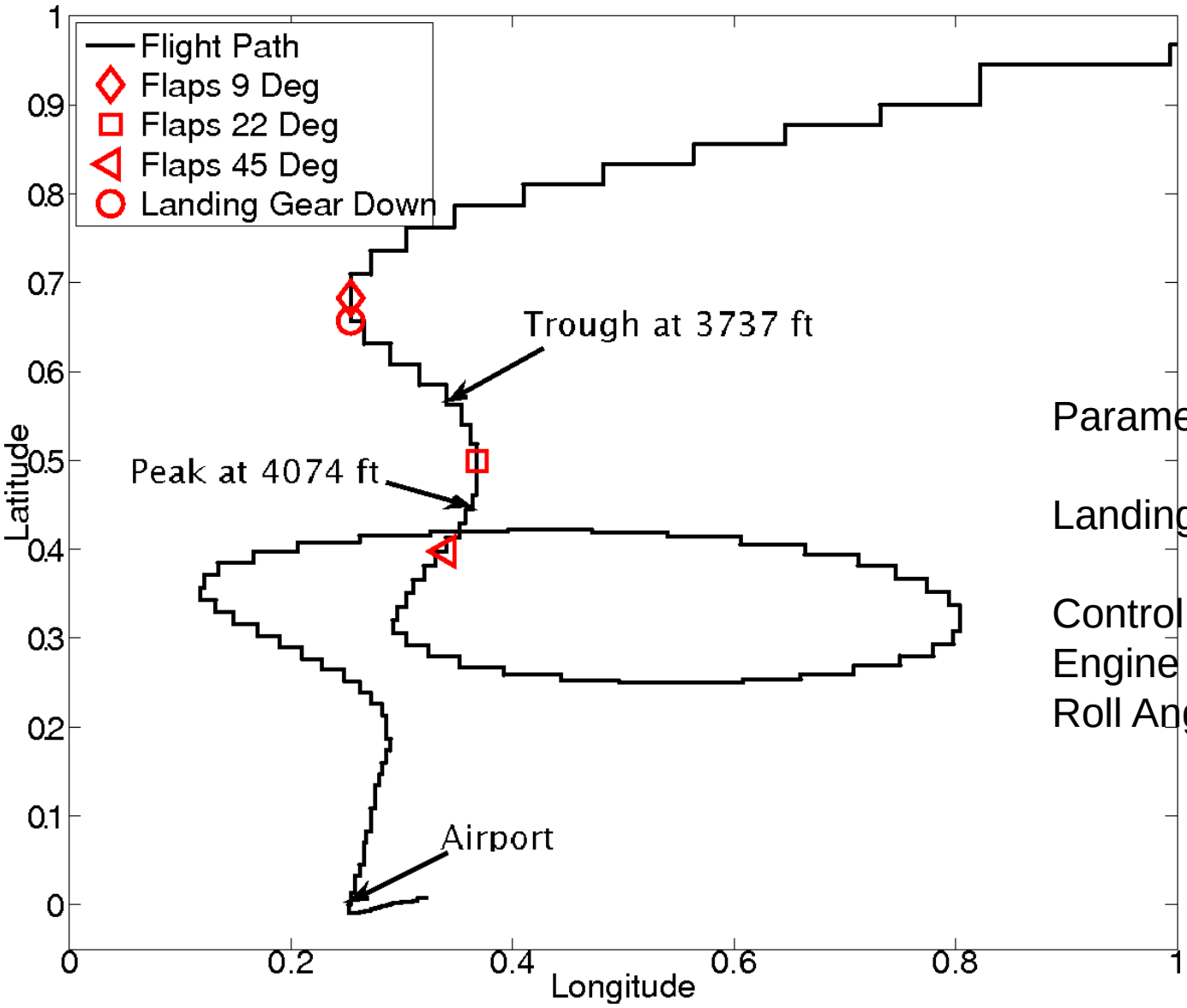
$$h(\alpha, \beta, f_z, \rho) = \sum_i \alpha_i \left(\sum_\lambda \beta_\lambda K_{i,z}^\lambda \right) - \rho$$

- **Multiple knowledge sources**
- **Combined effects of parameters**

Some Discoveries

- **High Energy Approach**
  - **This flight is an example of high energy approach. The pilot took some intelligent decisions and displayed some effective maneuvering actions to ensure stable approach and safe landing.**
- **Human Response to Environmental Disturbances**
  - **A very interesting anomalous flight where numerous pilot actions were required to accomplish the appropriate approach profile under turbulent conditions. Excellent example of human performance.**
- **Unusual Approach**
  - **Flight with a very unusual approach profile compared to the normal flights for a given destination airport. Demonstrates ability to find flights which may be vulnerable to instability.**
- **High Speed Anomaly**
  - **Some anomalous flights identified with high speed at low altitude when compared to the normal flight profiles for that destination airport.**

High Energy Approach: Lat-Long

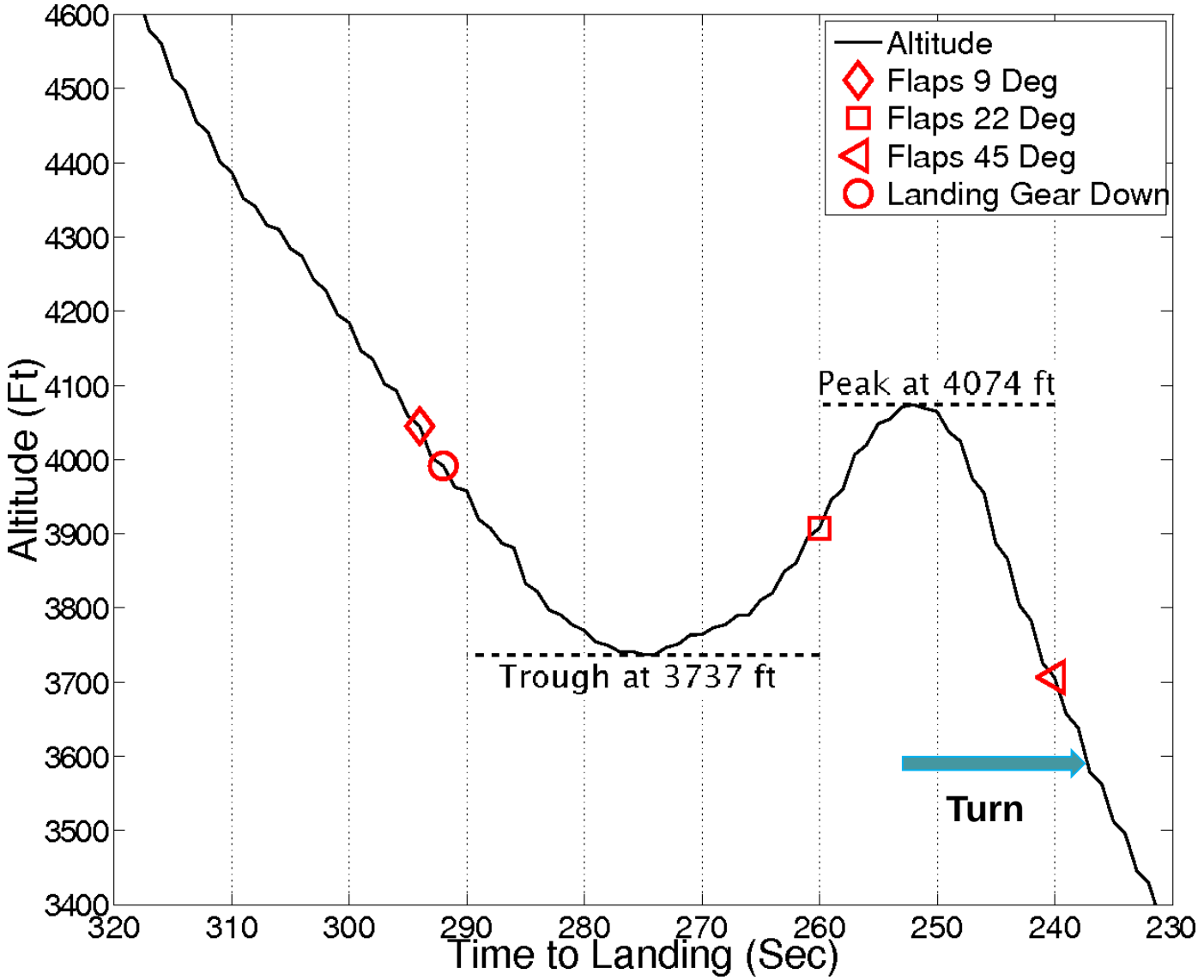


Parameters identified:

Landing Gear

Control Column Position
Engine Speed
Roll Angle

Climb during Approach



Abnormal Energy Dissipation

Flap 9 Deg configured

Landing gear deployed

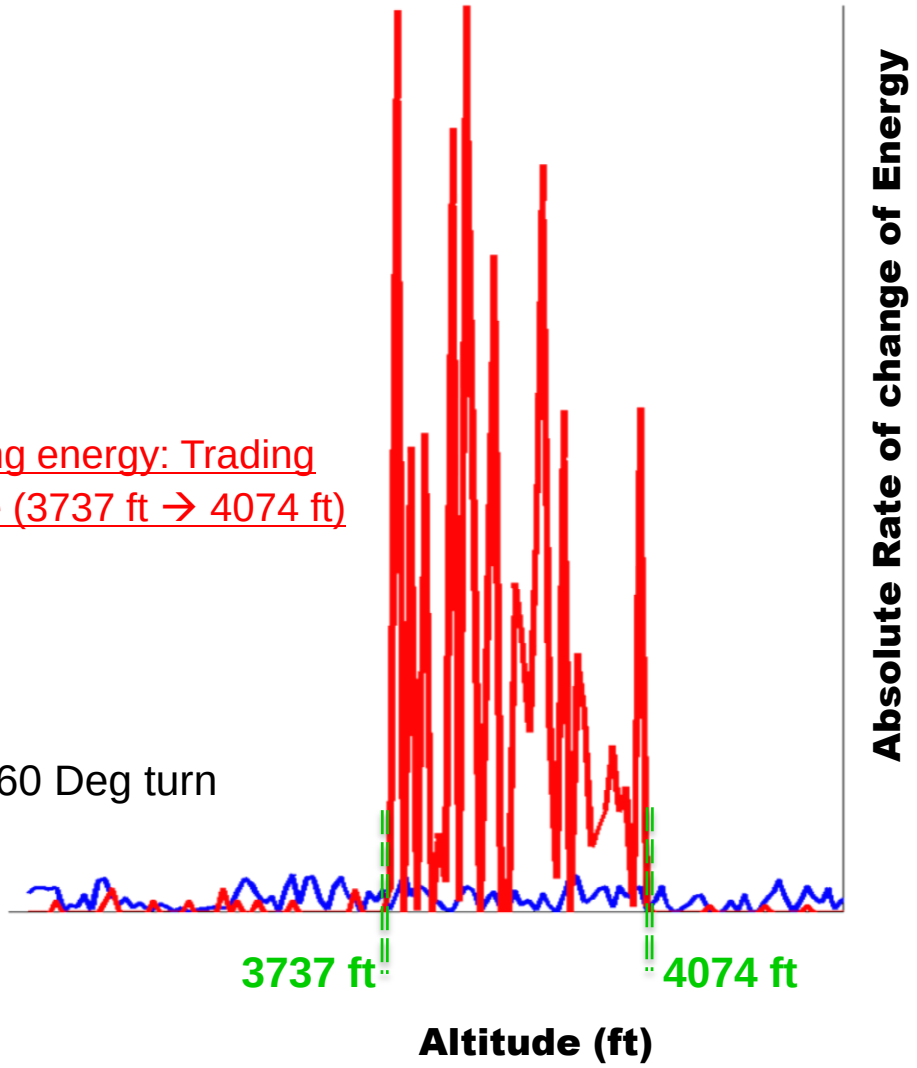
Too fast for Flap 22 Deg configuration

Quickly dissipating energy: Trading Speed with altitude (3737 ft → 4074 ft)

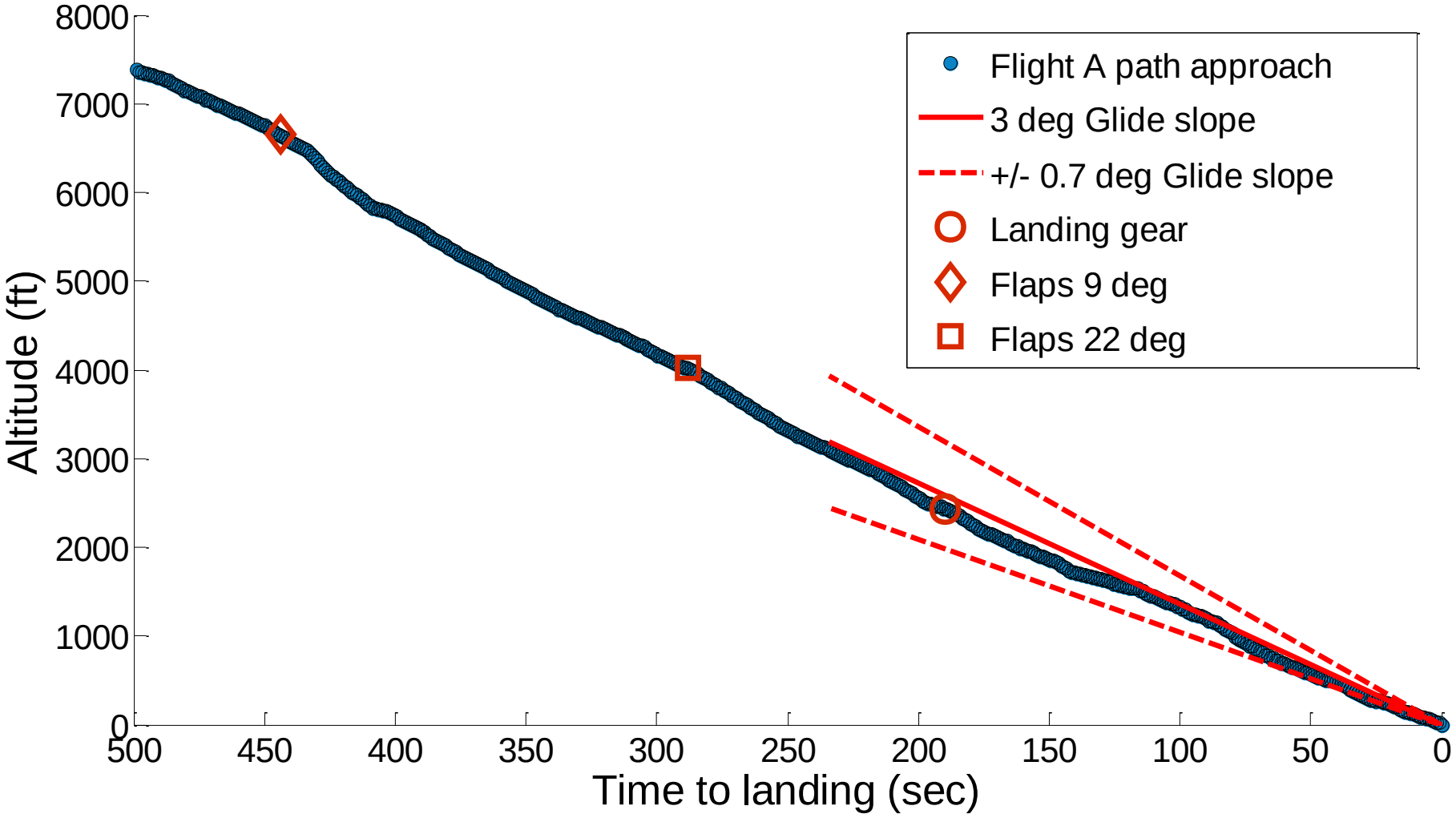
Full Flap configuration but too high Altitude for Stable Approach

Extra Maneuver: 360 Deg turn

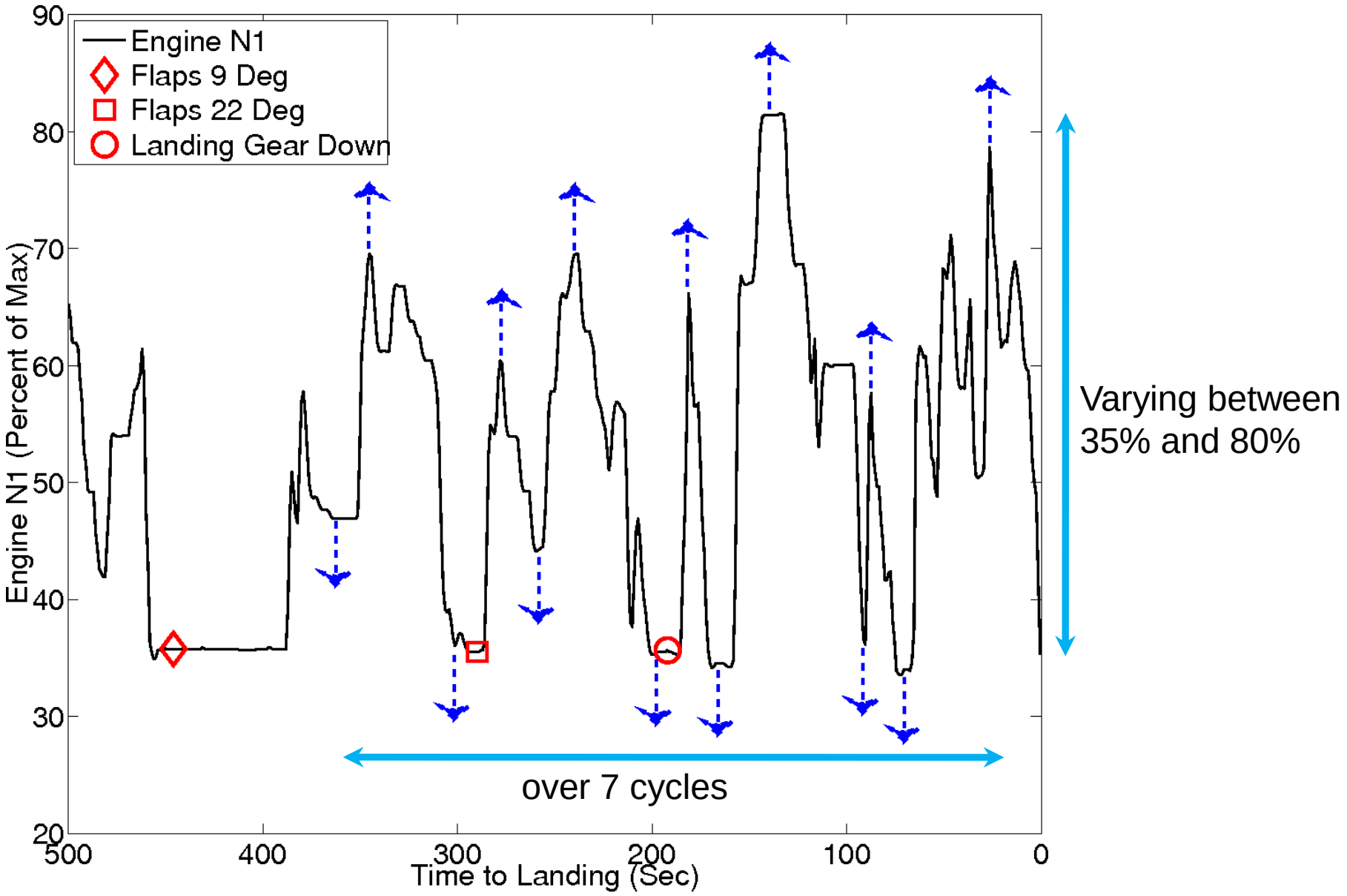
Met Stable Approach Criteria



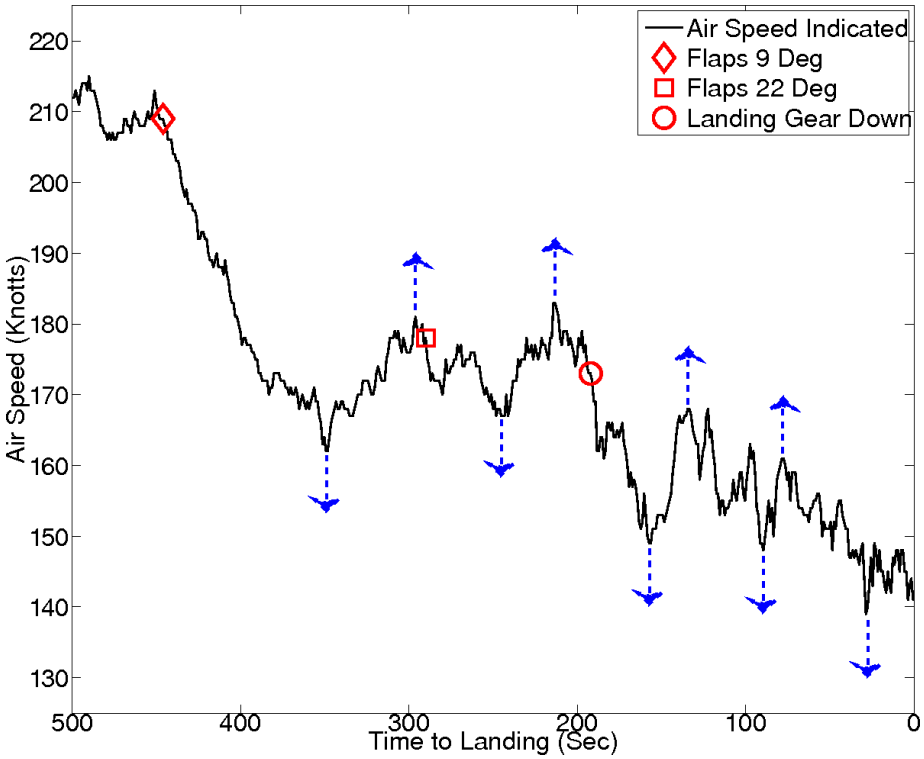
Human Response to Environmental Disturbance

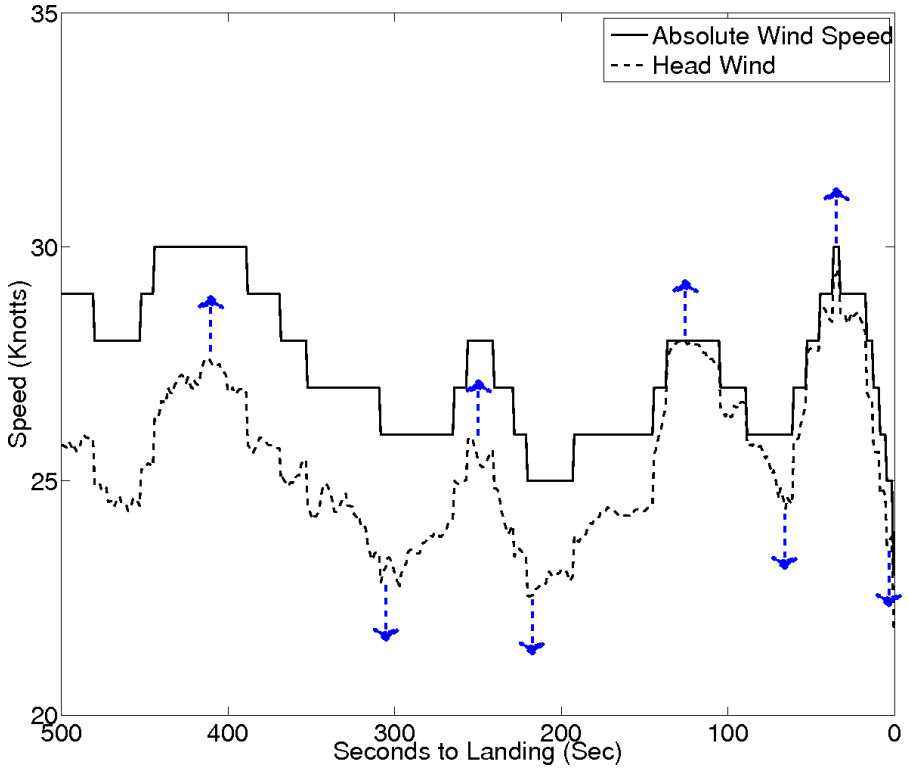


Engine Speed Variation



Gusty Wind Condition





Parameters identified:

Fuel Flow
Engine Speed

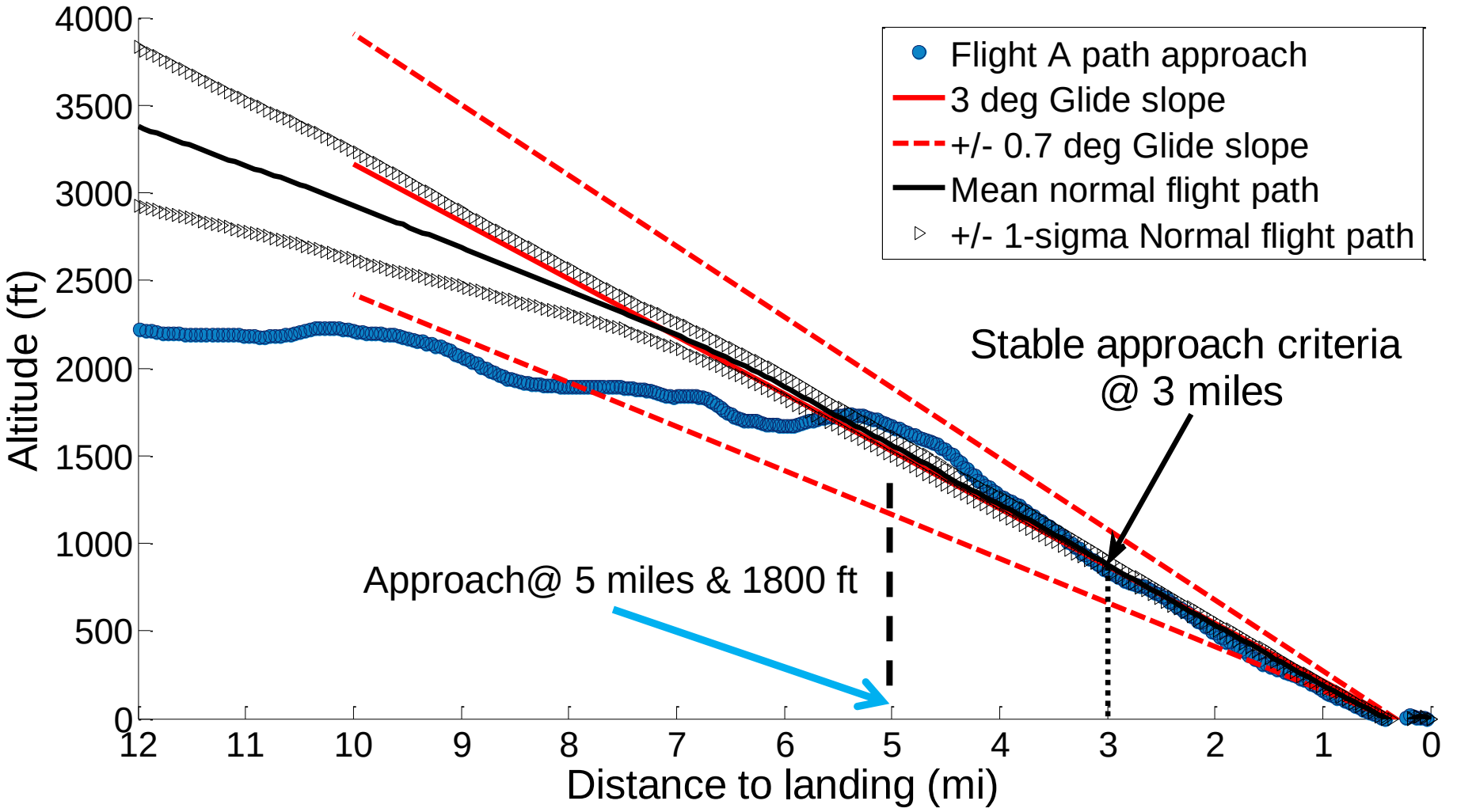
Flap 22 Deg configured

Why a safety issue?

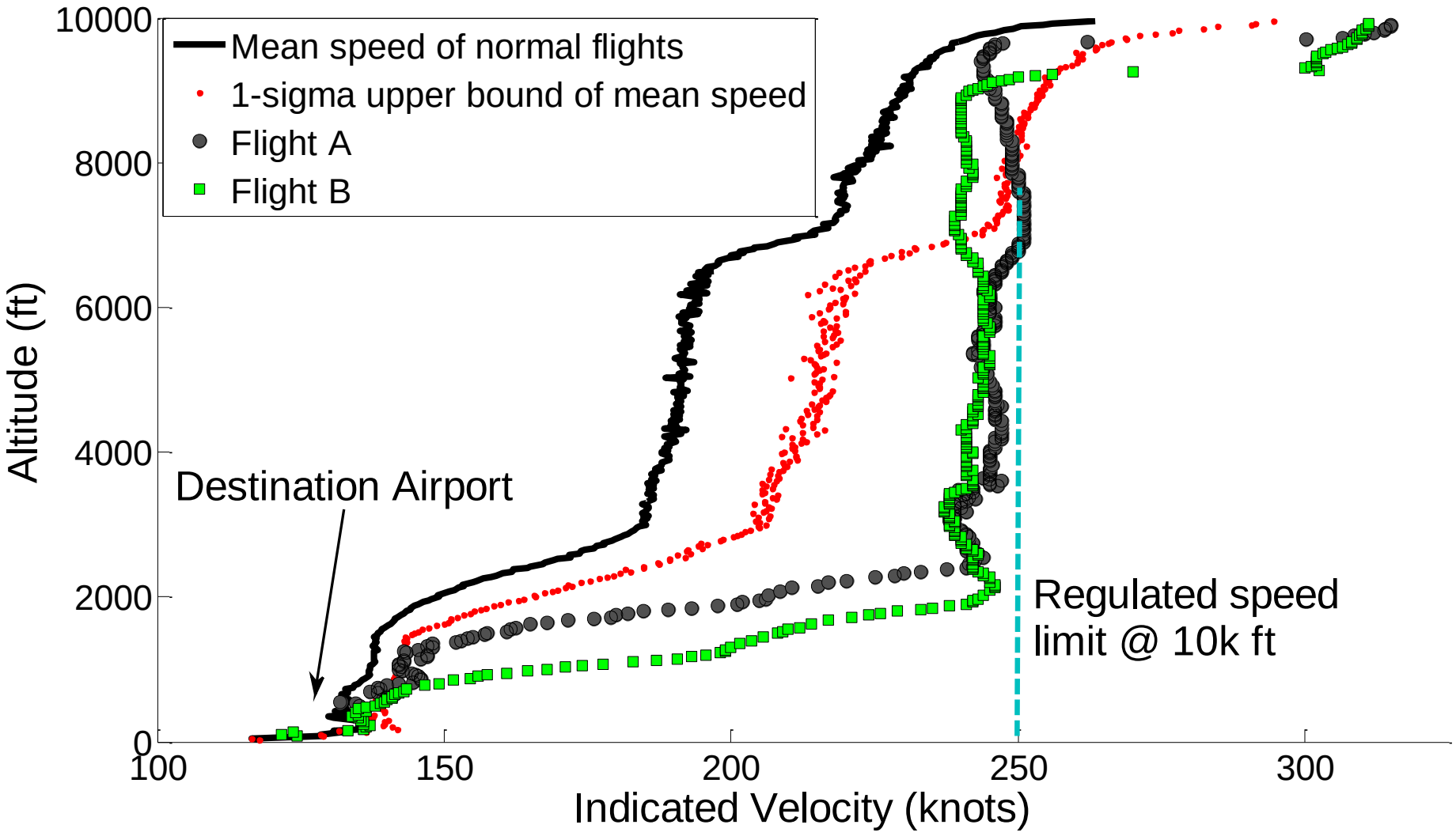
Turbulence & Change in Airspeed can result in Stalling

Note that the algorithm identified “pilot action” not “turbulence” as anomaly.

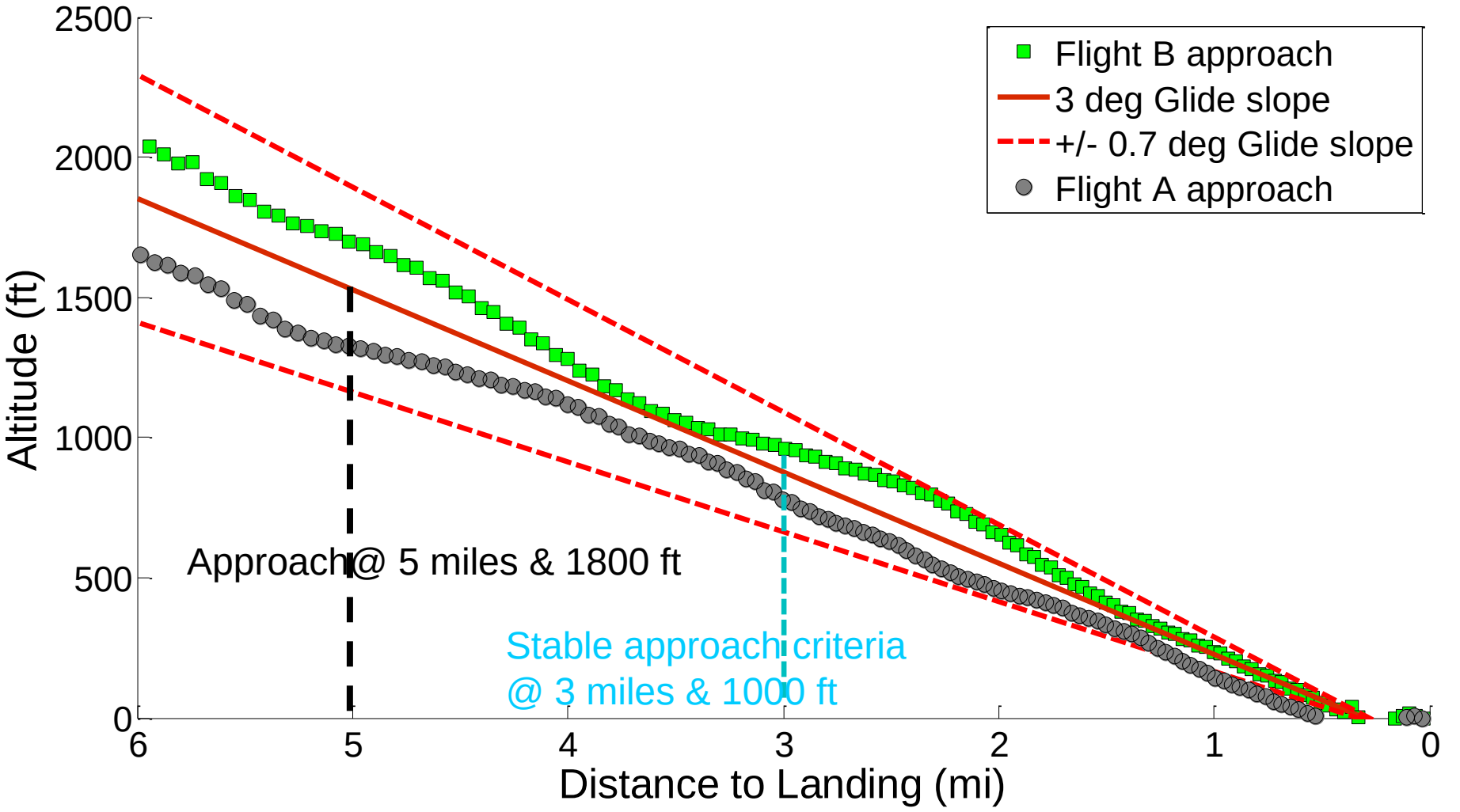
Unusual Approach



High Speed At Low Altitude



Glide Slope Profile



Why a safety issue? : Quick descent may result in hard landing or long landing and/or may fail to meet the stable criteria while meeting the glide slope from the top.

Thank you

- Top listed anomalies:
  - Data cleaning
- Ranking of anomalies
  - Top ranking are noisy /corrupted data and go-arounds

- New reporting scheme (ranking → clustering → ranking inside each cluster)

- Poster title: Analyzing Multivariate FOQA Data during Approach: Some Success Stories
- Contact and feedback:
  - Santanu Das

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- MKAD has been open sourced (available in Matlab)
- More resources on Dashlink website:

https://c3.ndc.nasa.gov/dashlink/resources/330/